Hot Iron

Issue 12 *"Journal of the Constructors Club"* **Summer 1996**

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Editorial

Many of you who know that farming is my main activity, might expect me to say something about those three dreaded letters standing for Blame Someone Else. In order to leave just a little space for electronic topics, the only sensible comment I can make is 'if you have not done so already, fill your deep freeze now because it will never be so cheap again'. I must say I am glad to have amateur radio as a diversion!

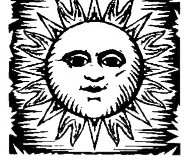
I was pleased to see many of you at the Yeovil ARC's QRP Convention which was held this year in a new location in Sherborne. The Digby Hall had a much more friendly atmosphere and there was a good attendance by amateurs and their traders which led to a jolly good event. As usual there was keen interest in how the entries for this year's Construction Challenge performed. The task was to make a 80m antenna and RX with only 12 components and no active devices. Excited by 1 Watt into a whip about 50 feet away, the highest DC output signals were in the order of 40 mVolts. Most were tuned loops with diode voltage multipliers. The Convention was one of the best that YARC has organised and most of that is due to the hard work of G3CQR. I hope that more of you in Southern England will be attending next year.

Products News

I pleased to receive several favourable comments from those building Brutons and Pitneys. After having two for evaluation, British Telecom ordered a large quantity of Pitneys for a Novice course which they are sponsoring in East Anglia. I was initially somewhat nervous about their reasons for wanting them since at that time, the good news about kits intended for amateur radio builders not needing CE certification for EMC, had not been announced. Luckily my concerns were ill founded! To go with the Pitney, I have designed a simple broadband CW crystal controlled 1.5 Watt TX called the **Drayton**. It can also be used with any other brand of RX. It is supplied with a ceramic resonator for 3.58 MHz; the on board trimmer allows about + or - 20 KHz swing. Simply by changing the crystal you can use it anywhere in the range 1.5 to 10 MHz. Since it is broadband, it must be used with low pass filters or a resonant antenna matching unit. It has a sidetone oscillator and control can be semi or full break-in and it has a netting facility. Price is £24 plus £1 P and P.

Progress on the Frome, which is the any-band CW rig, is a little slow due to pressure of other things. This will have a crystal mixing VFO scheme to give stability and avoid chirp. It will also have a very sharp adjustable switched capacitor low pass audio filter and some other frills not yet fit for announcing! I do also wonder if there is a demand for a crystal controlled receiver to go with the Drayton. Another job for the bath! Last time I wrote about the development of a signal generator and some of you kindly expressed an interest. Sadly this has proved to be a lot more difficult to get right than I imagined! Digital oscillators are nothing like sufficiently noise free and I have had to add a switched capacitor filter for the audio outputs since their third harmonic would unfortunately be in band. Although I was able to make the HF VFO give the desired coverage with a dead-bug version, when implemented with copper tracks there was too much stray capacity! The tuning diode voltage had to be raised to 30 volts needing an extra voltage boosting circuit. It has required several revisions and more proving which is not yet complete. My apologies! Tim Walford G3PCJ

Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Construction Club**. Articles on simple theory, construction, testing, updates on kits, questions and suggested topics are always wanted. Please send correspondence and membership inquiries to Upton Bridge Farm, Long Sutton, Langport, Somerset, TA10 9NJ. Tel & Fax 01458 241224 Subscriptions are £6 per year for the UK (£8 overseas) from Sept 1st in each year. June 1st 1996.



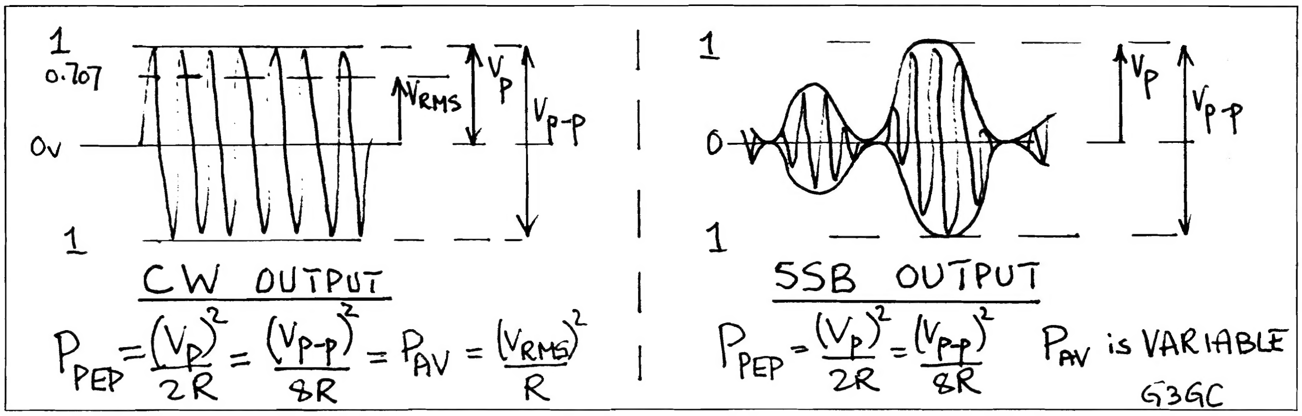
Peak Envelope Power

(This note follows a question from Stephen Melling G0WAF about the measurement of power; and for various reasons I thought I had better get Eric to explain!)

Peak Envelope Power (PEP) and its measurement always seems to cause some confusion among amateurs. According to the licence, PEP is the average power supplied to the load during *one RF cycle* at the crest of the modulation envelope. The lefthand diagram below shows a transmitter with a constant output (CW) and the righthand shows a typical modulation envelope from a SSB transmitter with the same peak output. In the left diagram, since the peak voltage is constant, the crest of the envelope is constant and the average power of each RF cycle is the same and equal to the square of the RMS voltage divided by the load resistance. Since the envelope contains a constant amplitude sine wave, the RMS voltage is the peak voltage multiplied by 0.707 (the square root of 2). The peak voltage can be measured with a peak reading voltmeter or an oscilloscope having a bandwidth well in excess of the signal frequency. (With a scope it is actually easier to measure the peak to peak voltage which is twice the peak voltage.)

When we come to an SSB TX output portrayed in the righthand diagram, the envelope is no longer constant but follows the modulation in both amplitude and frequency. This means that although the two example waveforms have the *same* maximum peak voltage, and therefore *the same PEP* because PEP measurement is defined as being averaged as over only *one* RF cycle; the actual average power dissipated in the load (considered over many cycles of the modulation envelope) is very much less and will be heavily dependent on the actual modulation. Any normal power meter will average the reading over several cycles of the envelope due to its mechanical inertia and thus give a reading much lower than is the case for the constant CW conditions despite the PEP of both waveforms being the same. It is for this reason that speech compressors are often used which, whilst not increasing the PEP, do increase the average power (sometimes loosely referred to as the 'talk' power) giving better readability at the receiver. A speech compressor usually reduces the peaks of the modulation envelope which allows the average modulation level to be increased to bring the peaks back to the same peak power level as before, thus uplifting the average power.

The formulae for the calculation of the powers associated with a load resistor R for the two waveforms are shown below them. Eric Godfrey G3GC



The 'times two' confusion! People often mistakenly think that the PEP figure for an SSB TX is twice the CW maximum power output figure - it is not! In fact they are usually the same! The origin of this misunderstanding is that the proper way to adjust an SSB transmitter is to use two audio oscillators having equal amplitude outputs feeding together in place of the microphone. (This gadget is called a two tone oscillator). A single steady audio input tone only produces a steady CW output in an SSB TX making it harder to detect output limiting. The two tone input produces an RF output whose envelope is defined by two antiphase sine waves of the same frequency; this waveform allows easy observation of limiting effects, usually in the output stage, with a scope. Provided the TX is operating linearily, on the peaks of this modulating envelope, the power (averaged over one RF cycle as above) *is* twice the power that the TX produces from either of the tones on their own. The transmitter output is then increased so that the peaks of this modulation envelope are just beginning to limit or clip. Then either tone is switched off and the RF power meter is used to measure the power in what is now a steady carrier due to the remaining single tone. The PEP figure *is* then twice this single tone figure and the PEP figure represents the maximum power that the rig can produce averaged over one RF cycle. I expect this is as clear as mud by now! It all leads up to a sales plug for the Walford Electronics two tone oscillator kit. This has a special diode detector section enabling proper CIO frequency adjustment without the need for a scope! It senses clean cross-overs in the modulation envelope with a DC voltmeter. G3PCJ

Introduction to Radio Frequency Design by Wes Haywood W7ZOI

A review by Mike Smith G7SDD who asks 'Is this a new Radio Designers Bible?'

The first time I saw Wes Haywood's book, *Introduction to Radio Frequency Design*, I knew I had to get a copy if I was going to do any serious radio design work. For the majority of us Radio Amateurs who construct equipment that can be considered as conventional, rather than pursuing the frontiers of radio technology, this book is an absolute MUST.

At first sight, it may appear a bit daunting, as it covers the fundamental theory of many aspects of radio design, and is liberally spread with attendant equations. Don't be put off by this if you are not mathematically minded, as there are plenty of practical examples which stimulates one into thinking more about the underlying principles rather than just copying the circuit. Even for those amongst the amateur fraternity who are at home with a bit of mathematics, the treatment of fundamental methods and models does not use any heavy maths, but keeps everything as simple as possible. (It does show how rusty we can get, though!)

Of particular value in my opinion, is Wes Haywood's treatment of oscillator design, filter design and network matching. These topics are absolutely fundamental to everything we do in RF design, and the way in which the subjects are presented is excellent. Even topics that we care not to think about, such as noise, noise models and noise matching, are all superbly covered. The book does not stop at models and simple treatment of the basic building blocks, but goes on to present an analysis of an overall receiver, covering front end and IF design, together with ways in which performance can be measured and evaluated,----- without recourse to sophisticated laboratory equipment.

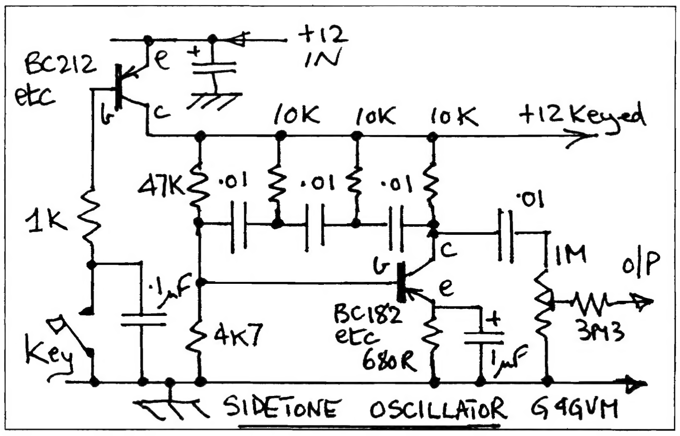
Naturally, it would be almost impossible to cover every possible topic and application in radio frequency design, and one area that is not covered in depth is large signal analysis, as would be applied to power amplifiers and driver stages. But there are plenty of references made to other literature that covers these specific topics. For those fortunate enough to have an IBM compatible computer, the book also comes with a 3.5 inch disk which has a host of extremely useful design tools, enabling one to devise filters, matching networks, attenuators, coils ------ and more. And what's more, the computer generated designs when translated into real hardware, work EXACTLY as designed. Magic!

The book is an ARRL publication and is available from the RSGB for £20.74 for members and £24.40 non-members. ISBN:0-87258-492-0 The disk alone is worth every penny! Mike Smith G7SDD

Phase Shift Oscillator Update

Referring back to Hot Iron Issue 9, further work has shown that keying the positive supply line with a p-n-p transistor is the simplest and least costly solution to the problem of how to key the oscillator. The circuit shown right still allows 'negative' keying which parallels up nicely with controlling the delay and changeover relay. This circuit avoids the need for any trimmers. Derek Alexander G4GVM

(Given the 3M3 in the output, it does need either a high impedance load and/or to be fed into an audio stage with significant gain such as a LM386 etc. G3PCJ)



Snippets

Nick Collis-Bird reports on the wonders of Hot Glue Guns available for about £8 from DIY shops. They are apparently perfect for tacking wires to chassis and it even sticks to aluminium which is notoriously unwilling to take glue. They are also useful for mounting S meters. The joints can be undone again if necessary.

Ray Donno reports a sad experience at the hands of a DTI radio inspector who called on a newly licensed amateur in the West Country. The poor fellow was put off the air, and his log suitably incised, for:-

a) having a TX that could operate outside the relevant amateur bands,
b) having a TCVR with a faulty display that read 5 KHz off frequency,
c) incorrect recording in his log, noting the band and not actual operating frequency,
d) not having any frequency counter or means of monitoring spurious radiation.

This all sounds pretty draconian and possibly debatable. It is important to be able to demonstrate that your rig does not produce spurious transmissions and to know your actual frequency - get your counters now!!

Ten and Twelve metres with the Taunton

Tony Measures G3WUC has spent a great deal of time working on these bands and assisting me with the development of circuits to provide the last two 'missing' bands in the Taunton's armoury. Originally I did not include 10 and 12m because they needed what appeared to be obscure crystals to obtain the correct local oscillator frequencies. With a 4 - 4.5 MHz VFO & 6 MHz IF, integer MHz crystals are needed to retain the same common VFO calibration for each 500 KHz segment as used on other bands. The easiest implementation requires 23 MHz for 12m and 10m needs 18, 27, 19, 28 MHz crystals. A 14.5 MHz crystal can be used for 12m but the band will start at 24.5 MHz at the VFO dial position where the normal bands start at X.00 MHz; similarly 18.5 and 19.5 MHz crystals would give the 28.5 - 29 and 29.5 - 30 MHz segments all tuning the same way as the other two segments of 10m. Subsequently I have located a source of 18 MHz crystals and Tony realised that 12m could be done with a 14.91 MHz crystal if the VFO calibration was completely different from other bands. This does not matter to him as he has a digital readout and could therefore use non integer crystals.

Having already changed all his single band plug-in cards for two band cards he had plenty of single band PCBs to experiment with! It did not take him long to get some action on 12m but only with rather reduced power. Feeding in signals from a signal generator had shown that the transmitter strip would work up to 10m provided there was enough drive. I was somewhat relieved to obtain this confirmation of my early development work which had 30 MHz as the intended upper limit for the IRF510 output stage. It was clear that an extra amplifier was needed in the transmit path; other experiments had shown that when the IF amp is fitted no extra receive gain was desirable so the challenge is to find a way of bringing this amplifier into circuit only on transmit for these higher bands and without needing any extra connector pins! His suggestion so far is to use the spare pin, normally used for controlling the choice of band A or B, as a means of getting +12T onto the band card when not being used with two band cards. The +12T then controls a relay and the extra amplifier.

Despite being a bit of a rat's nest, Tony has already managed several DLs and F5RRS near Geneva on 12m phone with the basic 5 Watt output of his Taunton from Warrington. As soon as this work is complete, I shall inform readers. I am very nervous of requiring expensive non standard crystals and do ponder about a special card with a phase locked loop to get the full coverage of 10m. The pragmatic alternative maybe non integer crystals and mandatory digital readouts - particularly in view of the experience reported on the previous page! Both Tony and I would welcome any comments. Tim G3PCJ

The 1996 Somerset Homebrew Contest

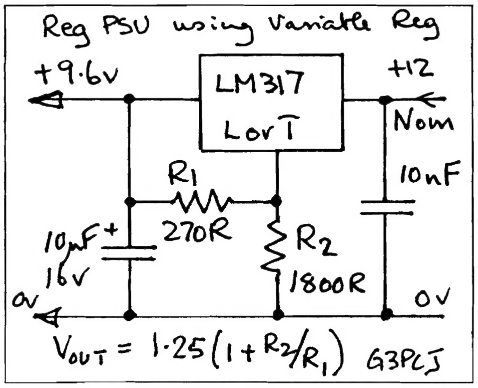
This was kindly organised by the G-QRP Club during March and I am pleased to be able to report the overall winner as VU2NGB; he operated only on 40m with an AM transmitter! The draw prize, available for all properly completed entries was won by our own Construction Club member Keith Edwards G3XUO using his Yeovil to good effect. Construction Club member Peter Burridge G3CQR also did well. I am discussing with Gerald Stancey G3MCK how we can ease the rules to encourage more entries next year. Star prizes in 1997!

The Pitney's Voltage Regulator

Just in case I have failed to notify all builders likely to be effected, the last batch of voltage regulators used in the Pitney proved to be rather more susceptible to insufficient capacity on their output compared to earlier batches. The LM2930T8 low drop out regulator actually needs 10 µF on its output to stop it oscillating. With insufficient capacity the output tends to apparently follow about a volt below the input when measured with a voltmeter. A scope shows a most unsteady output voltage instead of the desired straight line! Unfortunately the tolerance on many types of electrolytic capacitors can be -20% to perhaps +50% or more! For a few actual specimens C11 was insufficient to prevent oscillation. The cure is to replace C11 with a 22 µF part. If any body with a Pitney is suffering this problem and needs a capacitor let me know. G3PCJ

Comparison of voltage regulators

The standard 78XX regulators (where XX = output voltage) have line regulation of about 0.1%Vout against input voltage changes. The variable types based on the LM317 chip (suffix L is a 100 mAmp part, suffix T is 1.5 Amp) are much better with line regulation of about 0.01%Vout. Load regulation is also better at 0.1%Vout. This is why they are used for varactor diode tuning voltages. Low Drop Out (LDO) regulators are worse. The circuit for the variable types is shown right with the equation for output voltage. The values shown give 9.6 volt out - the practical maximum for a low nominal 12 volt input. Use plenty of output decoupling. G3PCJ

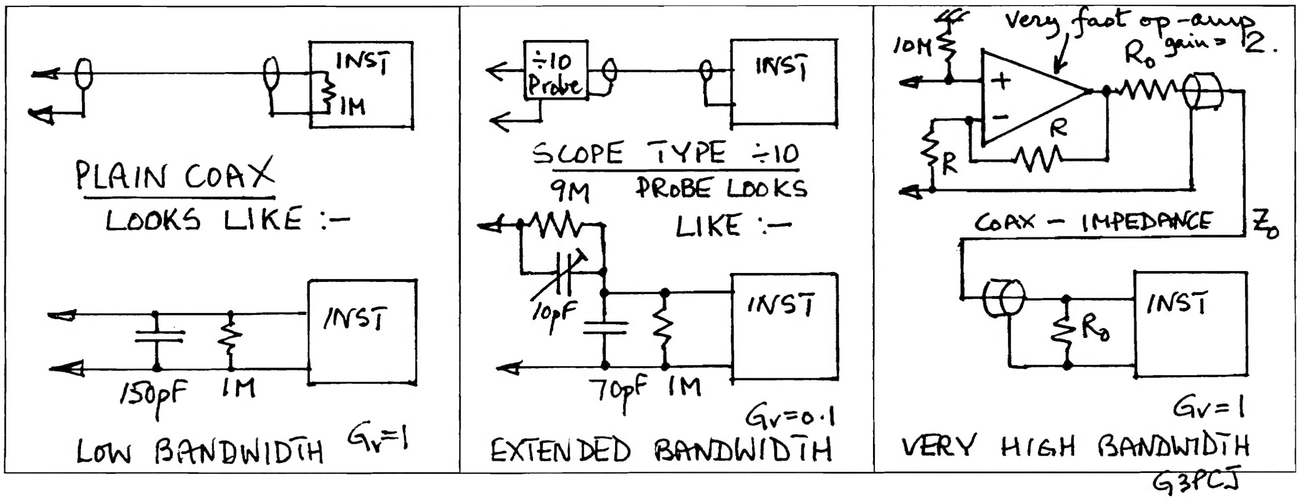


Test Leads and Probes

Quite often kit builders who are experiencing setting up problems with oscillators, ring me up saying that it doesn't oscillate or that it seems to be way off the intended frequency. Invariably these troubles are due to the leads to the test equipment! Questioning often reveals that the builder is using a plain piece of coax to connect between the oscillator and the instrument; perhaps a counter, RF voltmeter or sometimes a scope. At low frequencies, perhaps to a few KHz, this is all right but from 100 KHz upwards it causes severe problems. The reasons are that the piece of coax looks just like a capacitor, see left below. (A different situation exists if it is terminated in its characteristic impedance but this is seldom the case.) A typical test lead length of coax might have a capacity of 150 pF with a reactance of just over 1 KOhm at 1 MHz. Put across a 4 MHz VFO, the effect is even worse! Put this across some sensitive part of an oscillator, or almost any other RF circuit and it will cause havoc! It does not matter that the instrument may have a 1 MOhm input since when connected together, they are in parallel and still look like 150 pF or 1 K! It may sound odd, but it is actually better to connect the circuit to the instrument with the shortest possible single insulated wire. Do the same for both the signal and ground leads while keeping them apart; this will minimise the capacity and it might just work or give a reading!

A better solution is to use what are known as 'divide by 10' scope type probes. Here the probe is actually made up of a resistive attenuator arranged to divide the input signal by ten and provide a much higher DC load impedance than the basic 1 MOhm of the instrument. This is done with a 9 MOhm resistor in series with the probe tip - because this resistor is at the probe tip it isolates the cable capacity from the circuit under test. However the cable capacity is still there, and with the tip resistor, will act as an attenuator as frequency is increased. This effect is partially overcome by placing a small capacitor across the high value series resistor as shown in the middle below. In the ideal situation when C1R1 = C2R2 where C2 is the cable capacity and R2 is the instrument's input resistance, the range of frequencies over which the factor of 10 division applies is very much increased. As a guide C1 will be roughly one tenth of the cable capacity but to allow for manufacturing tolerances, it is usually made as a trimmer in the probe tip. (This trimmer is adjusted for the flattest top and bottom of a square wave signal applied to the probe tip and viewed with the probe attached to a scope. A suitable square wave is often available on the scope front panel.) To the circuit under test, the probe now looks like a few pF in parallel with several MOhms which is a great improvement and will be good enough for most HF applications. Occasionally the trimmer is fitted at the scope end of the probe cable.

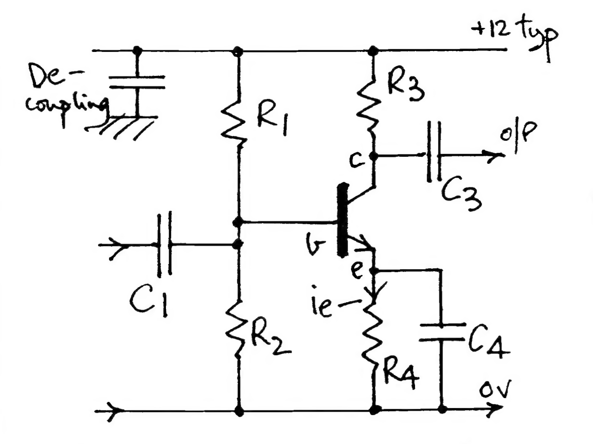
At even higher frequencies, or where impedances are high, it is necessary to go to an 'active' probe to fully isolate the cable capacity from the circuit under test. A very high speed op-amp is placed right at the probe tip and drives the cable as a transmission line terminated at both ends. The op-amp is usually an FET type with a gain bandwidth product near 1 GHz and an input that looks like a couple of pF in parallel with many MOhms; it is arranged to have a voltage gain of 2 to allow for the signal loss across the driving end termination. The arrangement is sketched on the right below. This could be a kit if anyone is interested. G3PCJ



Lightning Protection It is crashing away outside! Grounding the antenna system during a storm is reckoned to significantly decrease the chance of a strike on the antenna. I have a large 240 volt relay switch the feeders away from the AMU to a good RF ground (NOT mains earth) whenever the main shack 50 Hz supply is switched OFF. However, if it does strike the antenna, you will certainly suffer badly damaged gear!

The Common Emitter Amplifier

The box below shows a typical circuit. Given the lack of space, this assessment has to be rather simplified and without any feedback to make things easy! For convenience, it is assumed that the output is feeding a load impedance which is at least 10 times R3. (If not, substitute the value of R3 in parallel with the load for R3.) In this circuit, the purpose of R1 and R2 is to set the DC conditions in conjunction with R4. As the emitter current is almost equal to the collector current, the DC voltage across R4 needs to be a fraction of the supply voltage so that the available voltage swing at the collector is as large as possible. One quarter of the supply is a good starting point, which will mean that R3 is 3 times R4. If the supply is 12 volts then the emitter voltage needs to be 3 volts, and remembering that the base voltage will be 0.65 volts above emitter for a common bipolar type of transistor, gives a desired DC base voltage of 3.65 volts. R1 and R2 act as a potential divider to give this. The small signal voltage gain of the stage (collector AC voltage divided by base AC voltage) will be roughly R3 divided by the effective emitter resistance R_e. If C4 were absent, R_e would be nearly equal to R4 and the voltage gain would be R3 divided by R4 or a gain of 3 for the DC conditions suggested. If C4 is fully effective and decouples the emitter at the signal frequency then the effective emitter resistance in Ohms is approximately 25 divided by the emitter current in mAmps and the gain is much higher. The input capacitor C1 needs to be sufficiently large so that its reactance at the lowest frequency of interest is smaller than the parallel combination of R1, R2 and (20 times the effective emitter resistance as derived above). The output capacitor C3 needs to have a reactance smaller than the load impedance at the lowest frequency. The DC collector current needs to be at least a bit larger than the peak output signal current, (desired peak voltage divided by load impedance). Since this DC current also flows in the emitter, that allows R4 to be derived from the suggested 3 volts at the emitter. Output signal level will be limited by the lower of a) maximum available collector voltage swing, b) ~~inadequate DC current for the collector swing~~ and c) voltage gain times about 0.1 volts (due to non-linearity at the emitter when C4 present). The upper frequency at which gain begins to decrease, will be determined either by the transistor running out of gain as its gain bandwidth product is approached or when the reactance of the capacity at the collector (strays and device) is less than R3. This simple type of analysis is a useful guide for most small signal bipolar transistors of either n-p-n or p-n-p type. In selecting a transistor you must also make certain it has a sufficiently high collector voltage rating (at least 1.5x the supply voltage), sufficient maximum power dissipation for the collector current times voltage between collector and emitter, and adequate gain bandwidth product (known as F_T) for the application. A current gain or h_{fe} above 20 also is desirable. Since this is rather heavy stuff, a cartoon is in order! G3PCJ



SIMPLE COMMON EMITTER AMP

G3PCJ

Subscriptions

Sadly, it is that time of the year again! Unfortunately, the increase in the cost of postage and copying mean that I have to raise the subscription - it is however the first increase since we started the Construction Club three years ago and I trust that you find it good value. Feedback and articles are always very welcome.

From Sept. 1st 1996 I shall have to charge £6 but as a discount to existing members, I shall be pleased to renew your membership for the next year at £5 for UK members (£7 overseas) provided payment reaches my by Sept. 1st. Where membership was included with a rig, payment will be needed for next year.